Advances in Robotics & Automation

Asif and Webb, Adv Robot Autom 2016, 5:1
http://dx.doi.org/10.4172/2168-9695.1000145

Research Article Open Access

Contactless Medium Scale Industrial Robot Collaboration

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Received date: Feb 12, 2016; **Accepted date:** Mar 09, 2016; **Published date:** Mar 11, 2016

Abstract

A new age of industrial robotics is here which includes safety rated human friendly robots. These types of robots are more suitable in high volume and small scale industries. The operations in these areas can be fully automated. There are other industries which have specialty for low volume and high variability. High variety means there are less chances of fully automation as one product will be varying from other and in this complete automation is not viable option. The industrial robots which deal with high volume and can adopt variability through programming. There are plenty of manual operations which can be semi-automated. To address this human robot collaboration is a complete fit. The experiment has been undertaken to make one of these medium scale robot to collaborate with human to perform a task together. The contactless leap motion device has been used for controlling robot motions.

Keywords: Axis industrial robot; Contactless device, Human robot collaboration; Leap motion; Comau NM45

Introduction

The growing cost of High-Value/Mix and Low Volume (HMLV) industries like Aerospace is heavily based on industrial robots and manual operations done by operators [1]. Robots are excellent in repeatability by HMLV industries need changes with every single product. On the other hand human workforce is good at variability and intelligence but cost a lot as production rate is not comparable to robots and machines. There are flexible systems which have been specifically introduced for this type of industry FLEXA is one of them. But still there is need of collaboration between human and robot to get the flexible and cost effective solution [2]. A comprehensive survey has been conducted specifically on the issue of Human Robot collaboration [3] which laid out many advantages of this approach includes flexibility, cost-effectiveness and use of robot as intelligent assistant. There are several attempts have been made for Human Robot Collaboration for HMLV industry and Chen et al. attempt is one of them [4].

The conventional 6 axis arm robot is being used in several industries like automotive, aerospace, etc. Problem with these types of robot is they are not safety rated hence they have to be operated behind the cage and they have to be pre-programmed. The attempt of Human robot collaboration along with safety precautions has been made [5] in which they used 3D model and multiple depth images to monitor the robot cell. Other attempts to address safety has also been made [6] this case study used Pilz SafetyEYE and a SICK Safety Laser Scanner integrated via a Pilz Safety Relay. This safety system not only monitored the zone from top of the robot and assembly item but also under the robot arm and assembly item. Along with all these attempts to address safety of Human Robot Collaboration safety regulations has also been updated which allows Human Robot Collaboration in certain situations [7].

The research has been carried out in Cranfield University which shows the successful human robot collaboration using hand gesture control. The research used the Kinect Camera to carried out the task and monitor the zone. A case study for collision detection and avoidance has been presented which used 3D model of robot and depth images from Kinect camera [8]. The result shows that industrial robot can be used for human robot collaboration if safety systems are there to monitor [5].

The safety light curtains were being used in Boeing subsidiary of Australia where they used it for the safety of operator where operation needs manual intervention. The successful deployment of the system prove the little manual intervention of human for manual operation is safe with use of appropriate technology [9].

Human Robot interaction traditionally been done through teach pendants but that required trained operator. Other methods includes wearables like gloves. But these types of wearable technologies are not flexible enough in working environment as it needs frequently wearing and removing [10]. This can cause damage to the wearable and can potentially increase the amount of maintenance.

This paper presents a human robot collaborative system and their contactless interaction. A system in which operator can guide movements of robot using a contactless device. The leap motion is used as contactless device which does not need extensive training. A user with basic training can operate the system [11]. The use of light curtains enables to remove the cage around the robot to create feel of collaboration and enhances safety of the operator. The robot will stop movement immediately as the light curtains detect presence of operator on the boundary of cell.

The focus of our research is on human robot collaboration using contactless device like leap motion. The System used human hand guidance to move robot in certain direction.

Citation: Asif S, Webb P (2016) Contactless Medium Scale Industrial Robot Collaboration. Adv Robot Autom 5: 145. doi: 10.4172/2168-9695.1000145

Medium Scale Collaborative (MSC) Cell

System description

The system consists of medium scale industrial robot with 45 Kg payload. The robot used for this setup is Comau NM45 with C4G controller. The system also includes light curtains setup to remove cage and the Leap Motion device to move robot arm and control gripper. Figure 1 shows the system setup which includes following:

- Safety Light Curtains: For the safety of
- Leap Motion: To guide robot movement and control Gripper (end effector)
- Robotiq Gripper: It is three fingers gripper to grab items.
- Computer with Central Control Software System
- Comau NM45 Robot Arm with C4G Controller

Figure 1: MSC Setup.

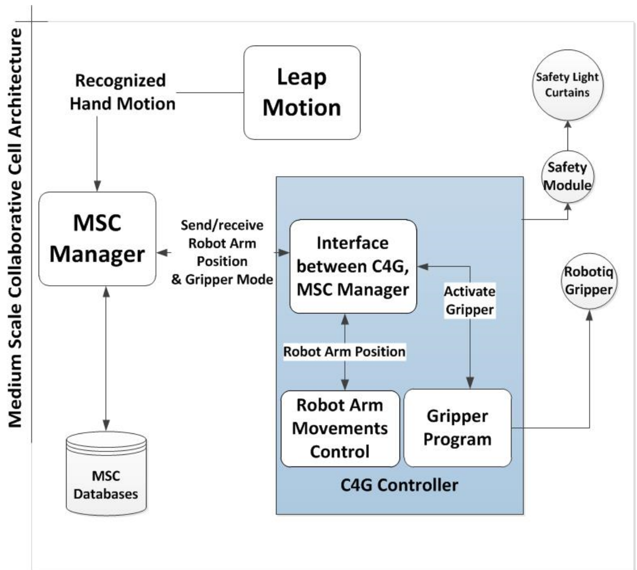

Figure 2: MSC System Architecture.

Architectural design

The system designed on modular architecture. It consists of number of sub systems/modules. Figure 2 shows MSC System Architecture which includes following main sub systems:

- **MSC Manager:** Which includes Control and coordination of all modules.
- **Hand Movement Detection:** Detects the movement of hands; Detects Gripping and un-Gripping.
- **Interface between C4G and MSC Manager**: Sen/Receives Robot Arm position and Gripping Data.
- **Robot Arm Movements Control:** Translates the received position into robot arm coordinates and sends the translated position to the robot; Sends the information back to the interface once robot arm been moved to requested position.
- **Gripper Program:** Controls the movements of gripper with specified force to grab/release the item.
- **MSC Database:** Stores System's data like points and Logs.
- **Safety Module:** Attached with the C4G controller it stops robot arm movement as soon as safety light curtains detects any obstruction between curtains.

Human robot contactless interaction

The system used two both hands to interact with robot arm using contactless Leap Motion device. The left hand has been used to direct robot movement towards Left, Right, Up and Down positions. The right hand has been used to control the gripper movement either open/close. Figure 3 shows the control movements with Left hand. Figure 4 shows the control of Gripper with right hand.

For each gesture except Close (for closing gripper fingers) users need to have fingers apart in order to recognize by leap motion.

The system starts with hand detection trigger. It determines the hand type whether it is left or right and then follows the procedure according to the detected hand type. If the hand is right hand then user

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can control gripper movements and can close and open the gripper depending upon the current arm position. The gripper movements can only be controlled if robot arm is in down position.

The left hand can control movements of robot arm and can use signals illustrated in Figure 3 to move the robot arm to the desired position. The flow of the system described in Figure 5 below. The system completely stops once light curtains detect any movement / obstruction between lights.

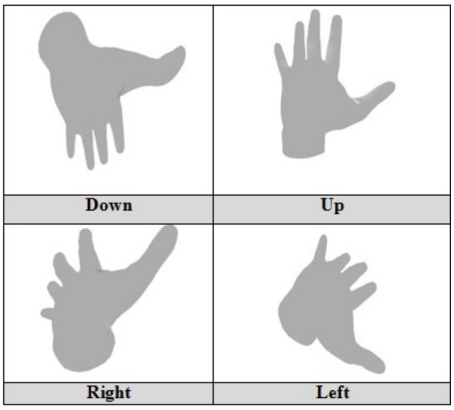

Figure 3: Left Hand Direction to Control Robot Arm Movements.

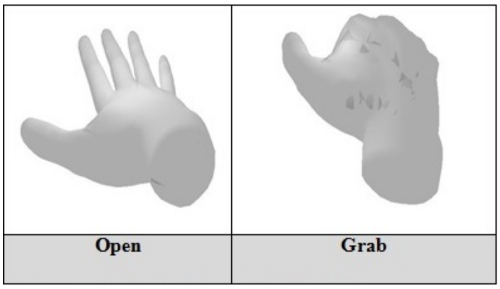

Figure 4: Right Hand to Control Gripper.

System Evaluation

The experiment has been setup to evaluate the system. A simple task was devised to fulfil the requirement. The user was asked to pick and place pipes from one position to another. Table 1 shows the Robot action according to user hand movements.

The pipe was originally placed on position A. The user was given task to move pipes between positions as illustrated in Table 2. The users were also given time to practice gestures before starting the actual task.

There were 6 participants from mixed professional background to perform the test which excludes the pilot test. Figure 6 shows the MSC setup on which participants performed tests. All participants were given same task as described in Table 2 above. Participants were also given time for training and practicing gestures.

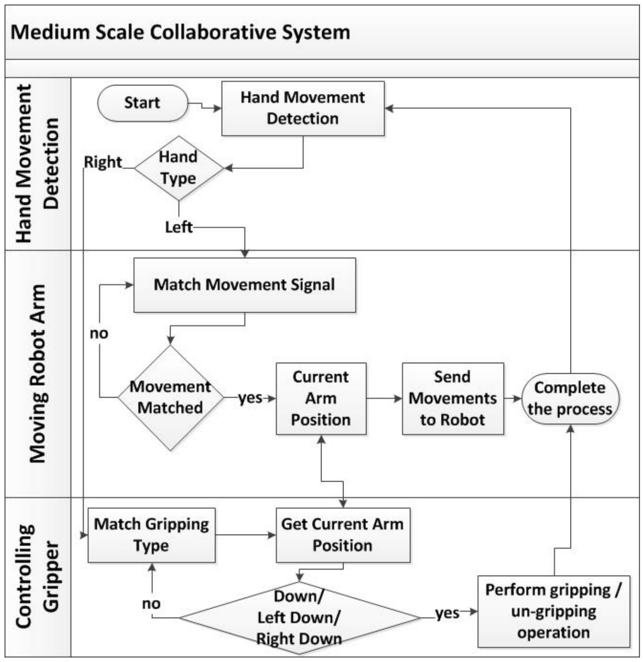

Figure 5: MSC System Architecture Data Flow.

Hand type	Hand position/movement	Action
Left	Hand flat above leap motion	Robot stops
Left	Tilt hand left	Robot moves to your left
Left	Tilt hand right	Robot moves to your right
Left	Tilt hand upwards	Robot moves up
Left	Tilt hand downwards	Robot moves down
Right	Grab fingers and thumb together	Robot moves gripper
Right	Pull fingers and thumb apart	Robot moves gripper

Table 1: Hand movements and robot actions.

Results and Discussion

System was recording participants' time to perform each gesture. A separate program was written to get participants' time and perform evaluation on data.

Figure 7 shows chart plot for the time taken to complete a single gestures. First 21 gestures data were taken for each participant to do the comparison. The mean gestures completion time was between 2 to 5 seconds. The Figure 8 shows the mean time to complete one gesture.

Total time to complete the task ranges between 1 min and 13 sec to 4 minutes 10 seconds. The mean time for all of the participants to complete the task was 2 minutes and 23 seconds. Figure 9 shows the total time to complete the test by participants.

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Step	Action
1	Pick up pipe A
2	Move pipe A to position C
3	Drop pipe at position C
4	Move to position B (Up)
5	Move to position C
6	Pick up pipe C
7	Move the pipe C to position B
8	Drop pipe at position B

Table 2: Test task description.

Figure 6: MSC Test Setup.

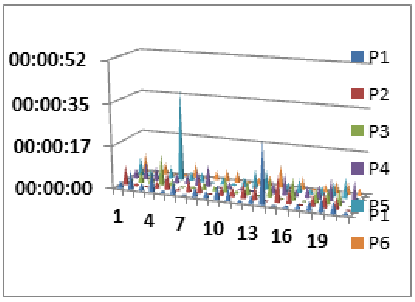

Figure 7: Time between Gestures – x-axis: gesture number, y-axis: time to complete gesture (sec).

The maximum time to finish same task was spent by participant 3 which is also reflective in Figure 10 as number of duplicate gestures were detected in higher number for that particular participant.

Total number of hand movements was range from 22 to 38 except for participant 3 whose hand movements recorded 88 in number as shown in Figure 11. This also proves the data shown in Figures 9 and 10.

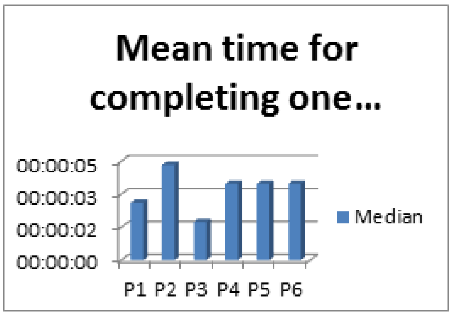

Figure 8: Mean time for completing one Gesture– x-axis: participants, y-axis: mean time to complete one gesture (sec).

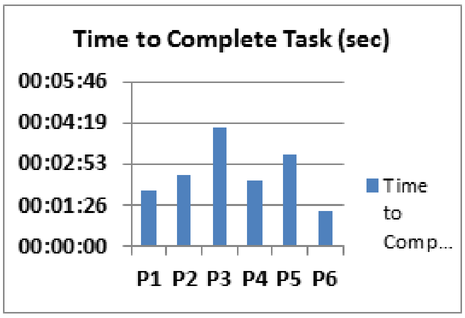

Figure 9: Time to Complete Task– x-axis: participant number, y-axis: time to complete task (sec).

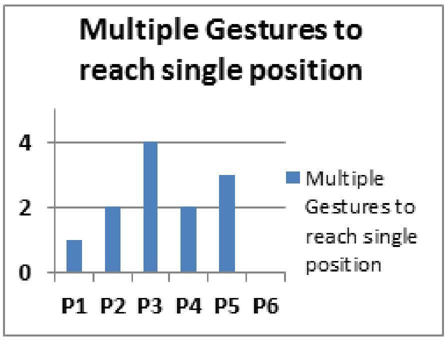

Figure 10: Multiple Gestures to reach single position – x-axis: participant number, y-axis: number of multiple gestures/duplicate gestures to reach single position.

The feedback taken from participants also reflects that for some participants hand gestures were not recognized merely on titling sometimes they have to move hand completely to get right and left movement. For other gestures this problem was not present. This shows room of improvement in generalizing the hand detection for different types of hands. There is also another impact on the test which was un-controlled light as we had bright sunny spells during the test. This also impact the efficiency of leap motion to detect hands and hence system to recognize gesture type. The lighting conditions were beyond control but one certain improvement can be made which is to

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generalize parameters to recognize left and right gesture for different hand types.

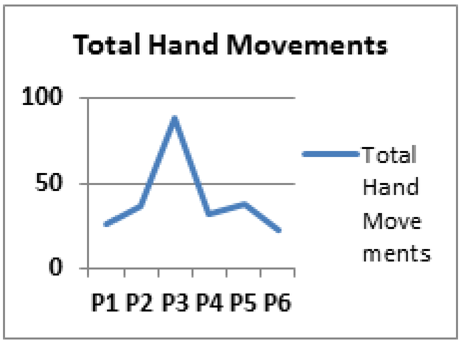

Figure 11: Total Hand Movements– x-axis: participant number, y-axis: total number of hand movements to complete task.

Summary

The experiment shows positive results for the contactless control of robot. Mean time to complete task for all participant was 2 minutes and 23 seconds which also shows the productiveness of system. However there is still room for improvement especially to generalize the hand's parameters for left and right gesture. This kind of case-study can be used in HMLV industry in which there is still need of manual intervention from operators where robot can act as assistant to the operator.

Acknowledgments

This research is supported by the EPSRC Centre for Innovative Manufacturing in Intelligent Automation. Particular thanks to to John Thrower, Senior Technical Officer in Cranfield University, for his technical input and Support.

References

1. Pycraft M, Singh H, Phihlela K (1997) The Volume-Variety Effect on Design. Operations Management, Pearson Education, Limited.
2. Webb P, Asif S (2015) Enhanced Cell Controller for Aerospace Manufacturing. Aircr Eng Aerosp Technol.
3. Krüger J, Lien TK, Verl A (2009) Cooperation of human and machines in assembly lines. CIRP Ann Manuf Technol 58: 628-646.
4. Chen F, Sekiyama K, Zasaki H, Huang J, Sun B, et al. (2011) Assembly Strategy Modeling and Selection for Human and Robot Coordinated Cell Assembly. International Conference on Intelligent Robots and Systems Pp: 4670-4675.
5. Schmidta B, Wanga L (2013) Contact-less and Programming-less Human-Robot Collaboration. Forty Sixth CIRP Conference on Manufacturing Systems pp: 545-550.
6. Hamilton A, Webb P (2015) Assessing the Safety Risk of Collaborative Automation within the UK Aerospace Manufacturing Industry. Safety-Critical Systems Symposium, Bristol, UK.
7. (2011) BS ISO 10218-2: robots and robotic devices – safety requirements for industrial robots Part 2: robot systems and integration. BS Institution.
8. Tang G, Asif S, Webb P (2015) The integration of contactless static pose recognition and dynamic hand motion tracking control system for industrial human and robot collaboration. Ind. Robot An Int. J 42: 416-428.
9. Atkinson J, John H, Jones S, Gleeson P (2007) Robotic Drilling System for 737 Aileron. SAE Int.
10. Neto P, Pires N, Paulo M (2013) High-level programming and control for industrial robotics: using a hand-held accelerometer-based input device for gesture and posture recognition. Ind Robot An Int J 37: 137-147.
11. Marin G, Dominio, F and Zanutiggh P (2014) Hand gesture recognition with leap motion and kinect devices. EEE international conference on image processing (ICIP).